

# **REACTOR VESSEL INSTRUMENTATION SYSTEM**

Chapter 3.1

# OBJECTIVES

1. Identify the purpose of the Reactor Vessel Instrumentation system.
2. Describe the ranges and calibration conditions of the reactor vessel water level instrumentation.
3. List the reactor vessel water level and pressure initiation, trip and isolation functions.
4. Describe the other parameters monitored by the reactor vessel instrumentation system.

# OBJECTIVES

5. Recognize the parameter setpoint and resultant action in tables 3.1-1 and 3.1-2.
6. Describe how the reactor vessel instrumentation system interrelates with the following systems
  - a. Reactor Vessel System (Section 2.1)
  - b. Reactor Core Isolation Cooling System (Section 2.7)
  - c. Feedwater Control System (Section 3.2)
  - d. Nuclear Steam Supply Shutoff System (Section 4.4)
  - e. Recirculation Flow Control System (Section 7.2)
  - f. Reactor Protection System (Section 7.3)
  - g. Emergency Core Cooling System (Chapter 10)

# PURPOSE

**The Reactor Vessel Instrumentation System provides indication of;**

- reactor vessel water level
- reactor vessel pressure
- reactor vessel temperature
- core flow rate
- core differential pressure
- vessel flange O ring leakage

**These parameters are monitored to allow safe plant operation and to provide initiation, trip and isolation signals for various safety systems.**

**Normal Water  
Level  $\approx$  17ft  
above TAF**

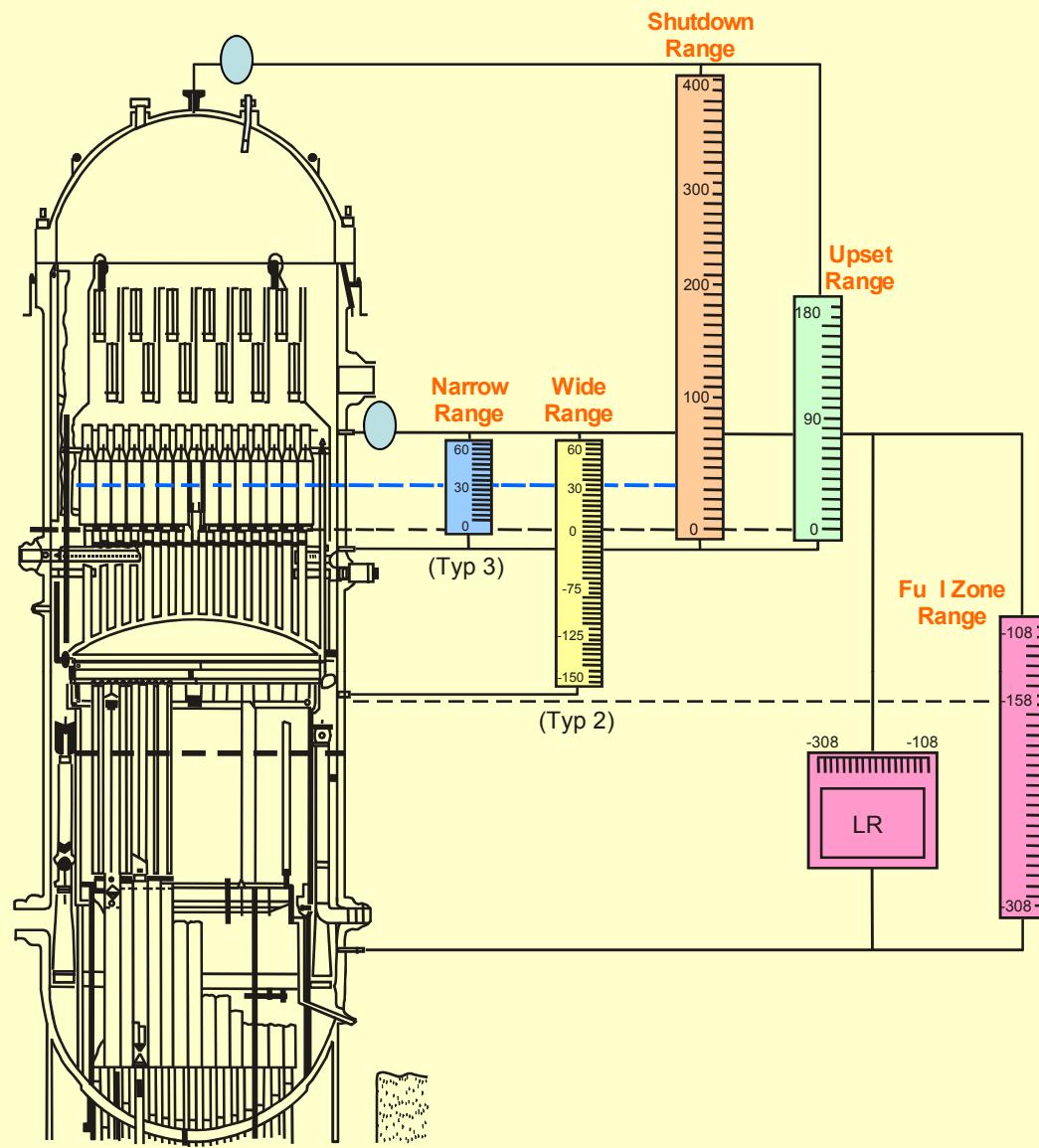
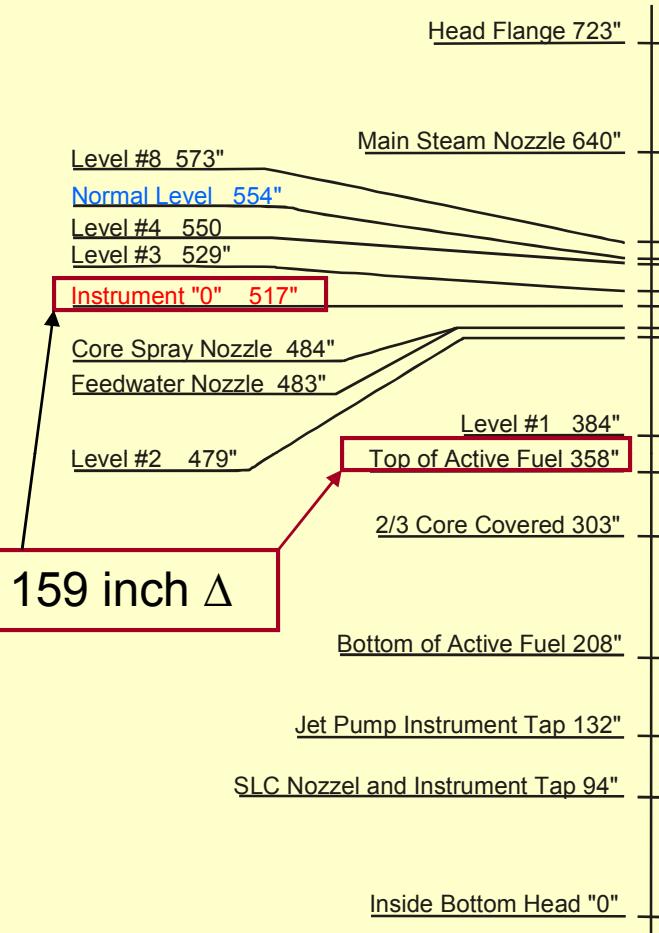


FIGURE 3.1-1 Vessel Level Instrumentation Ranges

# Calibration Conditions

<b>Level Instrument</b>	<b>Normal Operating Pressure</b>	<b>Normal Operating Temperature</b>	<b>Drywell Temperature</b>
Narrow Range (0- 60 inches)	1,035 psig	540 °F	135 °F
Wide Range (-150 to 60 inches)	1,035 psig	540 °F	135 °F
Shutdown Range (0 to 400 inches)	0 psig	120 °F	80 °F
Upset Range (0 to 180 inches)	1,035 psig	540 °F	135 °F
Fuel Zone *(-108 to -308 inches)	0 psig	212 °F	212 °F

\* No Jet Pump Flow

## Reactor Vessel Level

## Actions

**Level 8 (+56.5")**

Trip Main Turbine  
Trip Feed Pump Turbines  
Close RCIC Steam Supply Valve Close  
Trip HPCI Turbine

**Level 7 (+40.5")**

High Level Alarm

**Level 5 (+37")**

Normal Operating Level

**Level 4 (+33.5")**

Low Level Alarm  
Reactor Recirc Runback to 45 speed limiter  
(with concurrent loss of one cond. / cond.  
booster or feed pump)

**Level 3 (+12.5")**

Reactor Scram  
ADS Permissive signal for System Actuation  
Reactor Recirc Pump runback to 30%  
speed limiter  
RHR Isolation (Shutdown Cooling Mode)  
(NSSSS)

## **Level 2 (-38")**

Initiate RCIC  
Initiate HPCI  
Trip Reactor Recirc Pumps (ATWS-RPT)  
Trip ARI Valves  
Isolate RWCU System  
Isolate Containment and Selected  
Reactor Plant System via NSSSS  
Initiate RBSVS

## **Level 1 (-132.5")**

Initiate RHR (LPCI Mode)  
Initiate CS  
Start Diesel Generators  
Shut MSIVs  
ADS Actuation Logic Signal  
LOCA signal to Reactor Building Service  
Water System

# Level Setpoint Basis

## Level 8

- Turbines are tripped to protect them from carryover of moisture and subsequent blade damage.
- The tripping of RFP, RCIC and HPCI turbines prevents overfilling the reactor vessel.

## Level 7

- High level alarm that warns operator moisture carryover will start to increase.

## Level 5

- Normal control level for the feedwater system

# Level Setpoint Basis

## Level 4

- Steam carryunder begins affecting core flow rate due to Jet and Recirc. pump cavitation.
- Recirc. Runback with a loss of RFP, CBP or CP to lower thermal power to within capacity of a single RFP

## Level 3

- Rx scram before water carryunder the dryer seal skirt
- Scram to keep water level above the top of active fuel to allow for:
  - Decay heat boil off
  - Steam Void collapse
  - Loss of feed flow

# Level Setpoint Basis

## Level 2

- Low enough that HPCI & RCIC should not initiate without a loss of FW on normal scram
- High enough to allow RCIC to recover vessel level before Level 1 starts low pressure ECCS systems
- Recirc Pumps tripped to add negative reactivity and prevent pump cavitation.
- ARI initiated to insert negative reactivity
- Select isolations to stop any leaks from non safety systems
- RBSVS starts to clean air in RB in the event of a leak.

# Level Setpoint Basis

## Level 1

- High enough above TAF to allow low pressure ECCS to restore level before fuel damage
- EDG's start in case needed by LOOP
- MSIV's isolate to remove a potential leakage path.
- All non safety RBSWS loads isolate to preserve cooling water for the safety systems

# Level Setpoint Basis

- - 213.5" Containment Spray Interlocks
  - Level below -213.5" LPCI automatically overrides containment spray and SP cooling.
  - Can be overridden by the operator at P601

# **Reactor Vessel Pressure**

## **Actions**

<b>125 psig</b>	RHR Isolation (Shutdown Cooling Mode)
<b>310 psig</b>	Auto close Recirculation Pump discharge valve, during LOCA
<b>465 psig &amp; 338 psig</b>	Permissive for injection by CS and RHR, during LOCA
<b>1025 psig</b>	High pressure alarm
<b>1043 psig</b>	High pressure reactor scram
<b>1120 psig</b>	Trips Reactor Recirc Pumps (ATWS-RPT) Trip ARI Valves

# Rx Pressure Setpoint Basis

1120 psig

- Recirc Pumps tripped & ARI initiated to shutdown the reactor (assumes failure to scram)

1043 psig

- High pressure scram
- With SRV ops ensures margin to the RCPB limits

1025 psig

- High pressure alarm warns pressure is above normal operating band.

# Rx Pressure Setpoint Basis

466 & 338 psig

- CS and RHR injection valve opening pressure if initiation signal is present.
- Not opened before these pressures to protect low pressure system piping

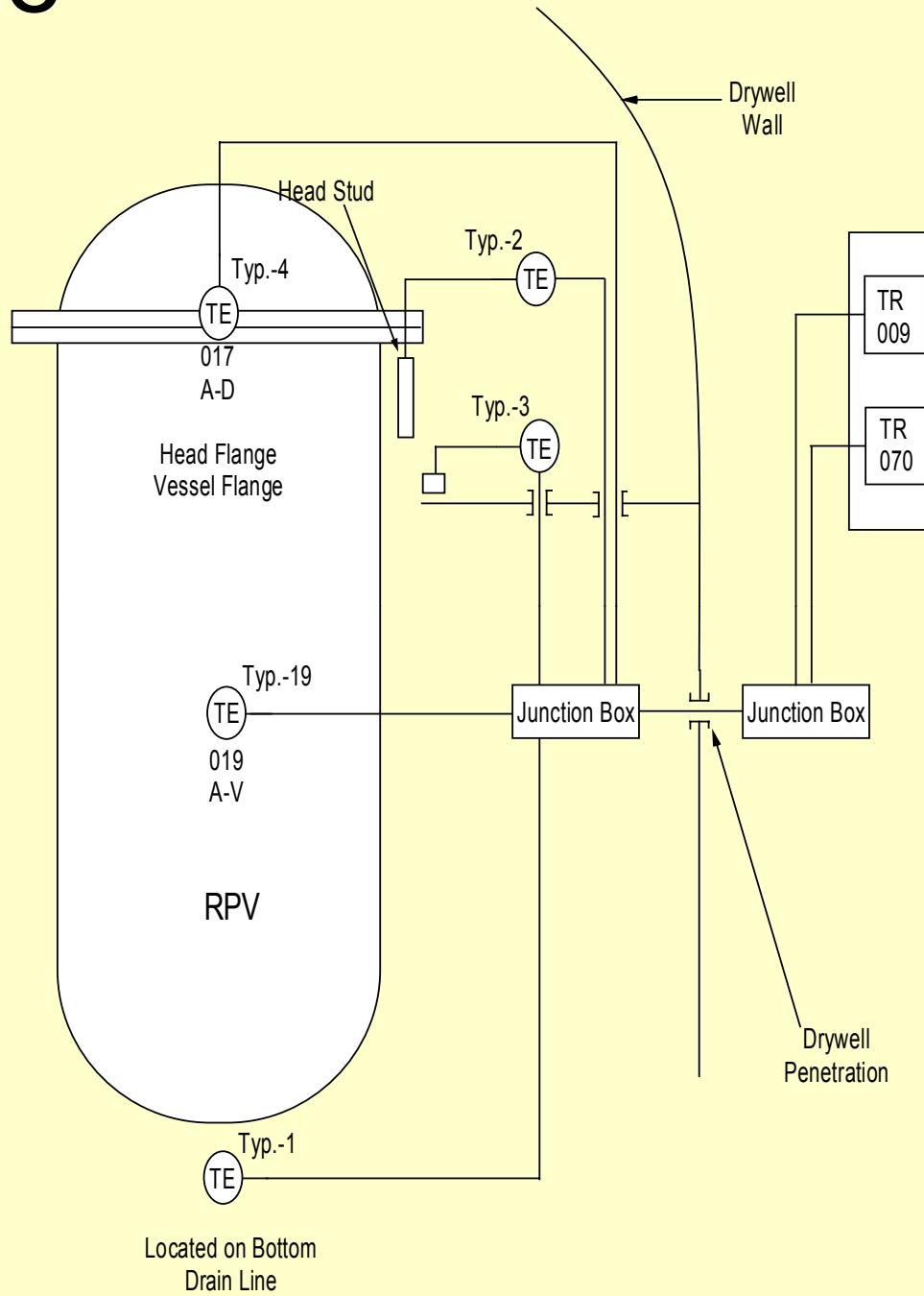
310 psig

- The Recirc. Pump discharge valves closure ensures flow directed to the vessel

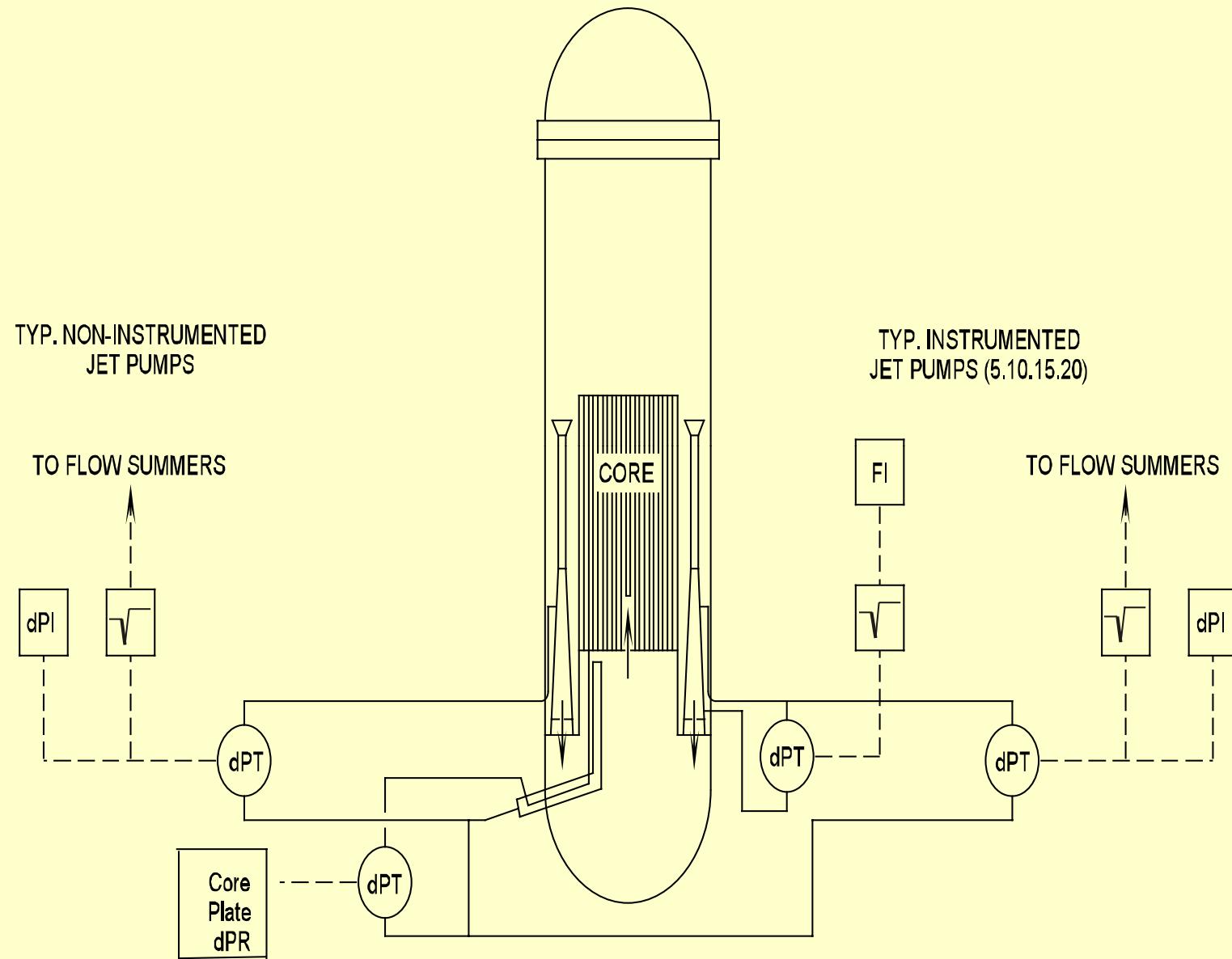
125 psig

- RHR SDC lines are isolated until this pressure to protect the low pressure piping.

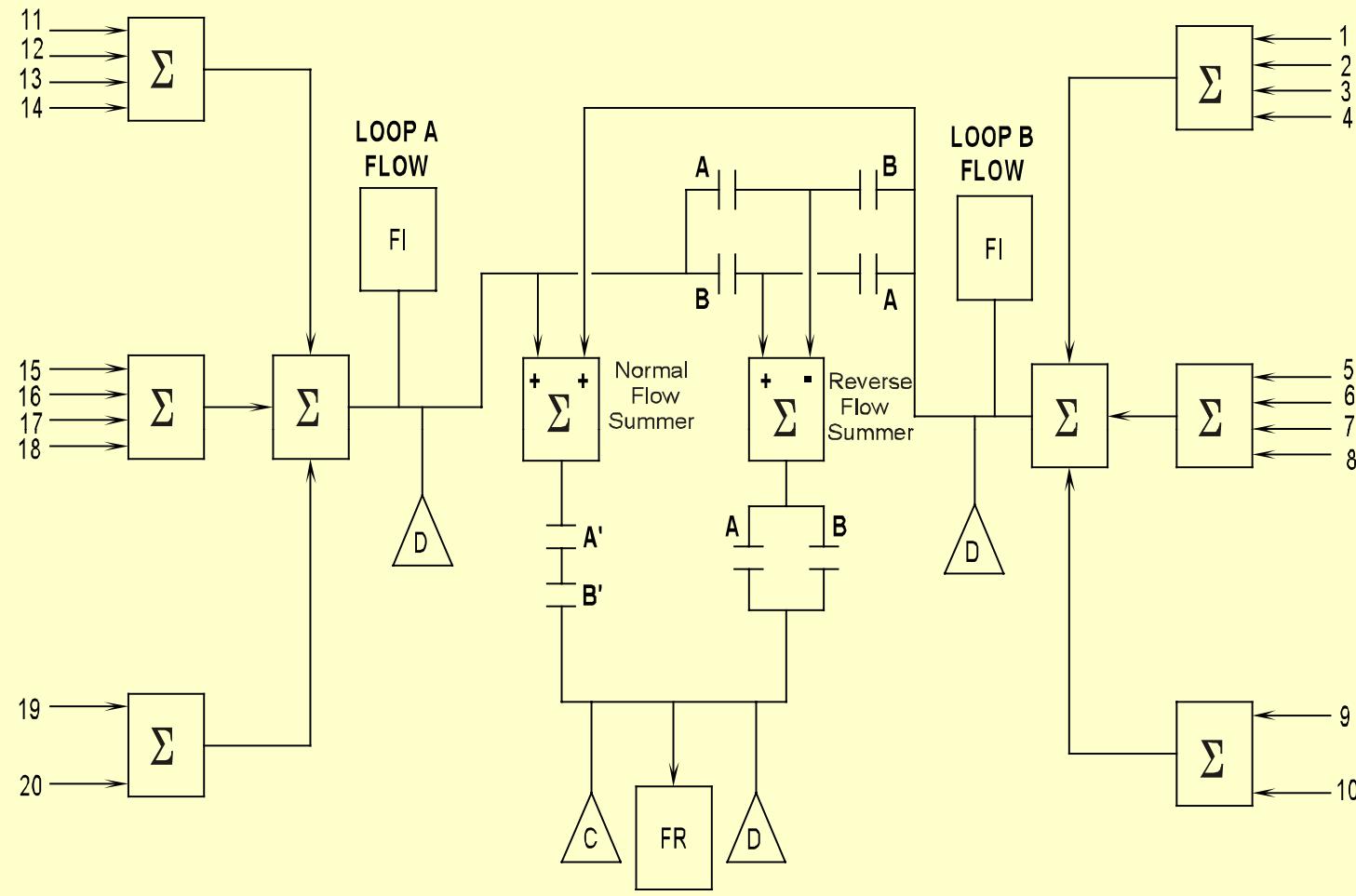
# Temperature Monitoring



# Core Plate and Jet Pump Flow Measurement

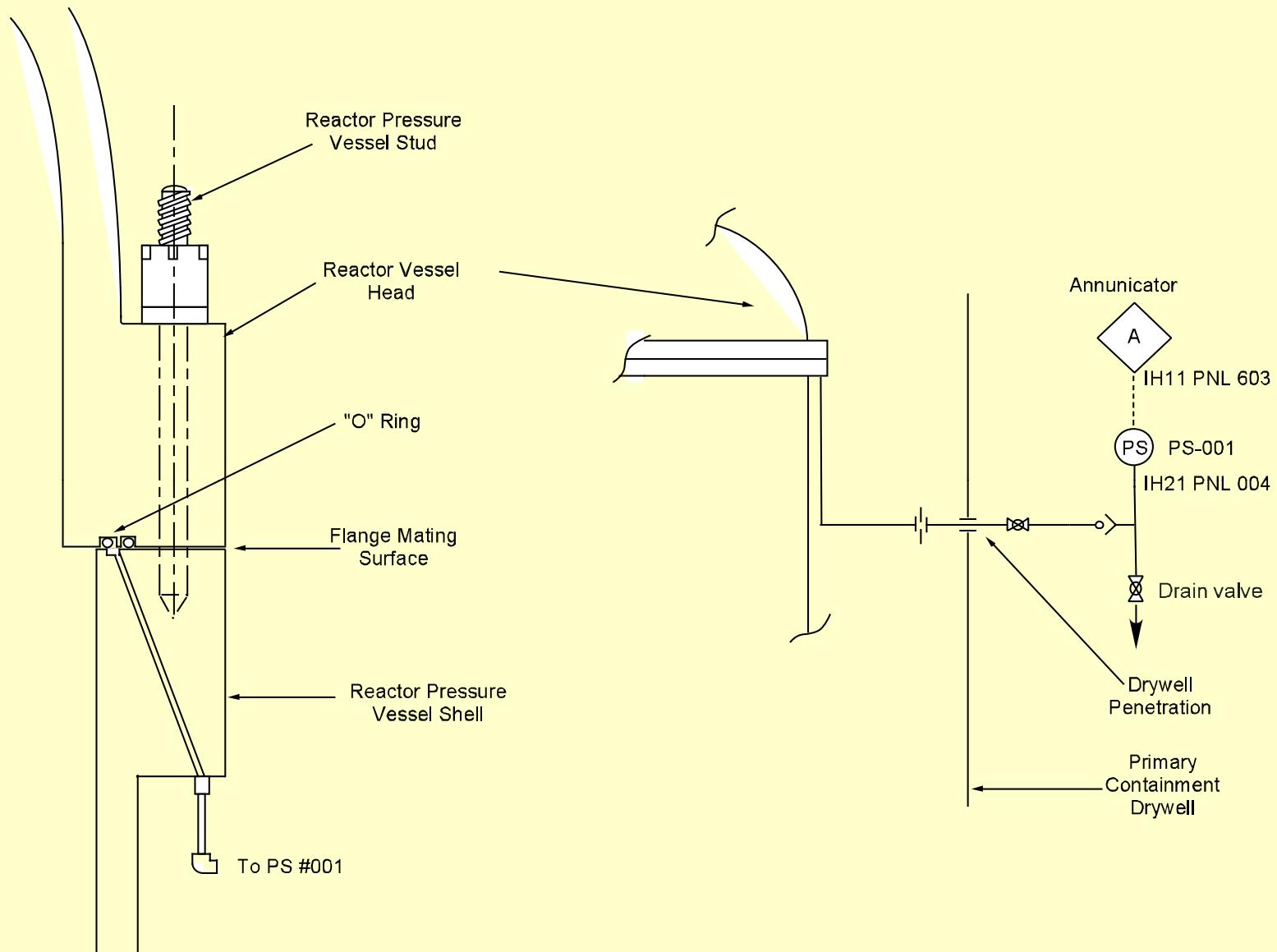


# Core Flow Summing Network



- A - SHUT IF PUMP A OFF AND PUMP B ON
- B - SHUT IF PUMP B OFF AND PUMP A ON
- A' - SHUT IF PUMP A ON OR PUMP B OFF
- B' - SHUT IF PUMP A OFF OR PUMP B ON

TOTAL  
CORE  
FLOW



## Vessel Head Leak Detection

# System Interfaces

## **Reactor Vessel System (Section 2.1)**

- The Reactor Vessel System is the sensing point for the various Reactor Vessel Instrumentation System sensors.

## **Reactor Core Isolation Cooling System (Section 2.7)**

- The RCIC System receives initiation and trip signals from the Reactor Vessel Instrumentation System

## **Feedwater Control System (Section 3.2)**

- The Feedwater Control System receives vessel level signals for control and display from the Reactor Vessel Instrumentation System.

# System Interfaces

## **Nuclear Steam Supply Shutoff System (Section 4.4)**

- The NSSL receives vessel level and pressure isolation signals from the Reactor Vessel Instrumentation System.

## **Recirculation Flow Control System (Section 7.2)**

- The RFC System receives level and pressure signals for runbacks and ATWS Recirculation Pump trips from the Reactor Vessel Instrumentation System.

## **Reactor Protection System (Section 7.3)**

- The RPS system receives level and pressure trip signals for Reactor Scram and ATWS ARI functions from the Reactor Vessel Instrumentation System.

## **Emergency Core Cooling System (Chapter 10)**

- The Emergency Core Cooling Systems (ADS, CS, HPCI and LPCI) receive initiation signals from the Reactor Vessel Instrumentation System.

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